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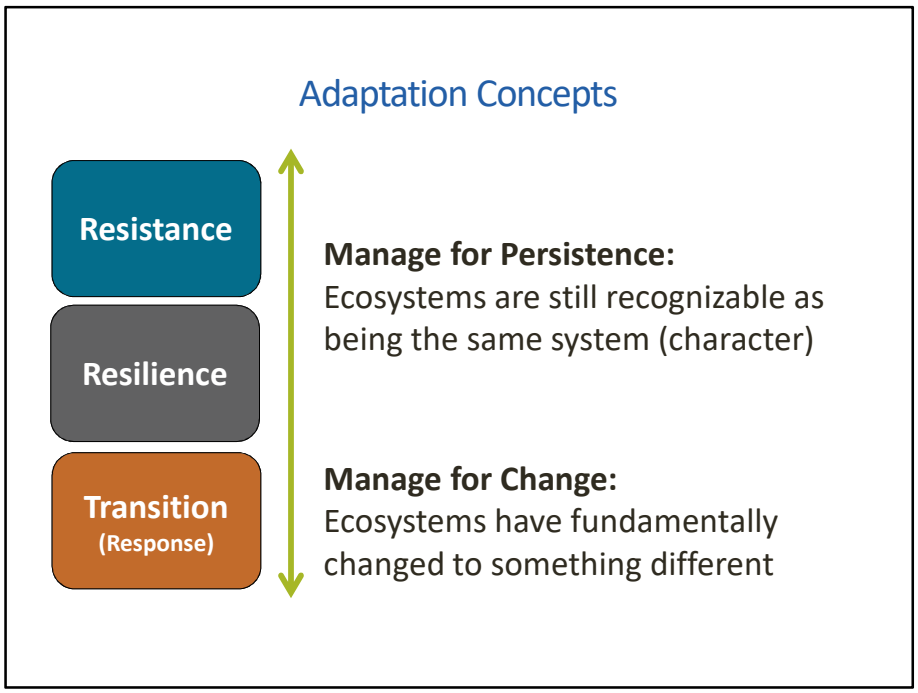
In this module, we will be covering concepts of climate adaptation for forestry and natural resource management, and discuss some of the common adaptation approaches managers are taking to reduce the risks posed by climate change in northeastern forests.

Adaptation is the adjustment of systems in response to climate change.

Ecosystem-based adaptation activities build on the sustainable management, conservation, and restoration.

So what is climate change adaptation? It is the adjustments we make to the systems we manage in response to climate change. These actions recognize the challenges and opportunities that climate change impacts and stressors pose for meeting the goals we have for our forests, and aims to reduce the vulnerability of forests to these. Ecosystem based adaptation builds on the actions we are already doing for sustainable management, conservation, and restoration of our forest resources.



The intent of adaptation actions will fall somewhere along the spectrum between managing to increase the resistance of the system to anticipated climate impacts, managing to enhance the ecosystem resilience, or managing to transition the system to something that is different from the current system and is better aligned to future conditions. These different concepts of adaptation can even be simplified into thinking about whether you manage for the persistence of the current system, or managing for a change to the system. No single solution fits all future challenges, especially in the context of changing climates, and so often the best strategy is to mix different approaches for different situations.

Resistance (persistence)

Required, or otherwise worth the risk

Improve the defenses of the system against anticipated changes or directly defending against disturbance in order to maintain relatively unchanged conditions.

Best for short-term, high-value goals

Reinforcing infrastructure along high value roads

Threatened & Endangered Species: Dwarf lake iris

Invasive species management

Millar et al. 2007, Swanston et al. 2016

Lets dive into these three adaptation options a little more. The first option on the continuum at the persistence end is "Resistance". This is often the focus in situations where we want to preserve critically important characteristics and functions, or we need to preserve and protect certain elements of the system. Actions focus on improving the defense, or directly defending the ecosystem against climate impacts to maintain unchanged conditions. Resistance actions are useful in high value systems unable to cope with disturbances & pressures from a changing climate. These actions are appropriate when there is a desire or mandate to maintain a resource with high economic, cultural, or ecological value. Resistance is often effective in short term, but will require greater resources and effort over the long term as climate shifts from historical norms. The classic example is building the seawall or adding a few feet to the levy to prevent flooding. Resistance actions in managing forests and watersheds can include increasing culvert sizing to accommodate larger stream flows, actions to protect threatened and endangered species, or preventing the establishment of spread of non-native invasive species.

Resilience (persistence)

Business-as-usual, but risk may increase over time

Accommodate some degree of change or disruption, but be able to return to a similar condition after disturbance.

- Improve overall system health & vigor
- Management of vegetation following disturbance

Prescribed fire

Upland forest management

Increased setbacks for fluctuating water levels

Holling 1973, Millar et al. 2007, Swanston et al. 2016

Resilience actions enhance the ability of a system to return to prior conditions after a disturbance. Although some degree of change may occur, the intent is for the system to return to a state similar to what it was before the disturbance. By allowing disruptions to occur, this adaptation option accommodates gradual shifts in climate, which is good for systems that can tolerate a wide range of environmental conditions and disturbance. In other words, resilience is often effective for systems with high adaptive capacity. The goals of resilience actions include improving the overall health & vigor of systems, and managing vegetation following disturbance.

Examples include restoring fire to fire-adapted systems, upland forest management, such as thinning stands or managing uplands for increased water storage by leaving coarse woody debris to help slow the flow off of the land. The last example here is increasing setbacks at existing wetlands to reduce disturbance pressures and allow for fluctuations of water levels.

Managing for resilience is often business-as-usual in contemporary land management. It's fundamentally still a persistence option but offers more flexibility and allows for changes. But because you want the system to stay the same over time, the risk of failure increases as climate stresses add up over time. And so

resilience is effective until the degree of change exceeds the ability of the system to cope – resulting in transition to another state.

Transition (change)

Mixed risk. May challenge values, precautionary principle.

Intentionally encourage change, help ecosystems respond in a targeted fashion

- Foster well-adapted native species
- Manage relocation/assisted migration
- Increase connectivity for migration
- Accommodate new & altered hydrologic processes

Planting seedlings of future-adapted species

Favoring existing native species better adapted to future conditions.

River & riparian area restoration on former agricultural fields

Millar et al. 2007, Swanston et al. 2016

Where resistance and resilience foster persistence of the current system – transition intentionally facilitates change, transforming the current system into a different ecosystem with different characteristics that still holds value. Also called "response" – this option is intentionally accommodating change to help ecosystems adapt to changing conditions. Managing for transition is good for highly vulnerable ecosystems where we think the current system has a high risk of failure when managing for resistance or resilience. Transition actions are designed for long-term effectiveness. Often transition actions are phased into broader management plans that have a near term focus on system resilience. Sometimes transition actions are good if a critical threshold is anticipated to be crossed... sort of a "if this happens, then we will do these things to transition the system". It is important though that the system being transitioned to still holds value.

Transition has mixed risk: in the short term, seedlings might fail. For example, if it's a colder than average winter, or a particularly dry growing season. Managers sometimes highlight the importance of considering the precautionary principle when thinking about managing for changes to a system, taking caution when thinking about introducing new species to an area.

Examples of transition include planting stock of future-adapted species that aren't

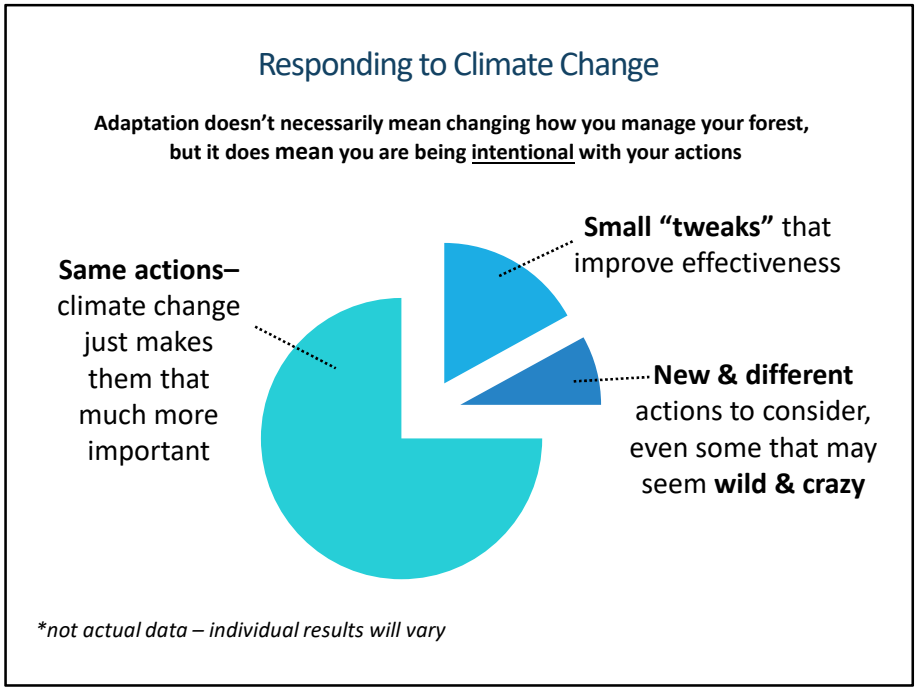
currently present in the region (assisted migration); favoring existing native species expected to be adapted to future conditions such that forest composition would be changed over current conditions; and restoring ecosystems, including historic forest composition or structure, if the restored systems are expected to be better adapted to future conditions. This includes restoring former floodplain marsh areas for storage of water – changing the hydrology of the system to act in a different way causes an ecological transition.

Adaptation is the adjustment of systems in response to climate change.

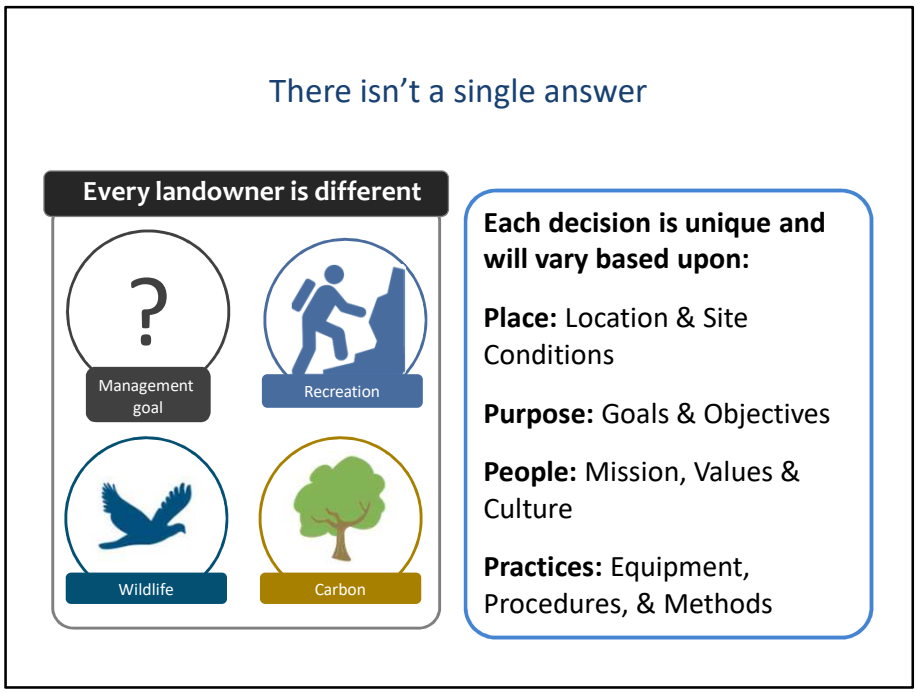


- What do you value?
- How much risk are you willing to tolerate?

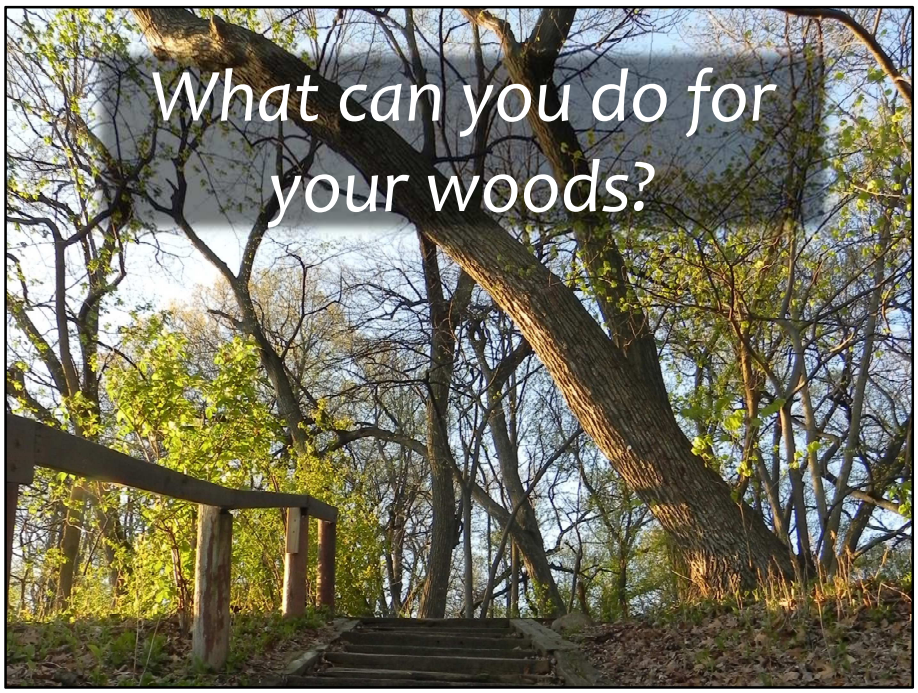
Values and risk tolerance, whether explicit or not, underlie virtually all discussions about adaptation. Come back to these when internal or external discussions seem unclear or counter-productive –unspoken differences in values or risk tolerance are likely the source of confusion.



Adaptation actions are designed to specifically address climate change impacts and vulnerabilities in order to meet climate-informed goals/objectives. Management actions might be the same or similar to what you're already doing, but it's necessary to explore potential modifications to address climate change risks. Often most of the adaptation actions people decide on are the same actions they had been already planning on, particularly when people are doing good forestry, and climate change just makes them even more important. Often people will have a set of actions where they have made small tweaks to improve the effectiveness, such as altering the timing, location, or intensity of an action. Often times people stop there, and sometimes people identify an even smaller set of actions that are truly new and different, usually in light of an important climate change impacts they realize they have not been addressing in their management. It is crucial to recognize, however, that good forest management provides the foundation for adaptation.



Recognizing that every landowner is different, with a wide variety of management goals, it is important to stress that there is no single solution, no one-size fits all answer to integrating climate change into forest management. Many resources available to you to help you consider how to adapt to changing climate, such as the Adaptation Workbook, provides flexibility for meeting any management goal because it is driven by the managers who tailor it to meet their specific needs. So get creative!



So lets look at some of the different approaches people have identified for climate adaptation in forest management. These are based off of the “Menu of Adaptation Strategies and Approaches for Forestry” resource included in the Forest Adaptation Resources document included in your resources list.

Improve your forest's defenses against unwanted change (resistance).

Protect water and soils on your land.

Good road and trail systems

- Improve access
- Concentrate impacts to designated locations

Stream crossings

- Ensure culverts and bridges can withstand extreme events
- Temporary bridges to protect habitat for fish and aquatic organisms
- Protects water quality

The first strategy to highlight is "Improving your forests defenses against unwanted changes", which is fundamentally a resistance option. One way to do this is to consider actions that protect the water and soils on your land. Actions you could implement include improvements to your road and trails systems to improve access and concentrate impacts to certain locations. Stream crossings may also be important to consider to protect aquatic habitats. Actions might include resizing culverts or bridges to withstand extreme events.

Improve your forest's defenses against unwanted change (resistance).

Prevent and control non-native invasive plants .

Early detection and action

- Stress or disturbance from other causes can allow plants to establish or expand
- Learn your local offenders!

Images: Invasives Plants Atlas of New England (www.eddmaps.org)

Another approach under the general strategy of improving your forests defenses against unwanted changes is the prevention and control of non-native plants. Actions include early detection and removal, and monitoring following disturbances. Certainly knowing what species to be on the lookout for is important as well.

Improve your forest's defenses against unwanted change (resistance).

Improve ability of your trees to resist bugs and disease.

Early detection and action – again!

- Promote healthy and vigorous trees
- Remove unhealthy trees
- Stress or disturbance from other causes can increase risk from pests or diseases
- Specific treatments for different insects and diseases

Images: USFS Northeastern Area, Mass Audubon

A third approach is considering actions to improve the ability of trees to resist insect pests and disease. Actions can include promote healthy and vigorous trees and removing unhealthy trees, and limiting stress from other causes, such as competition for soil moisture in areas with soils with limited water holding capacity. Specific treatments for insect pests and diseases may be an option for high value trees.

Improve your forest's defenses against unwanted change (resistance).

Protect rare or sensitive plant and animal communities.

Consider what is special or sensitive in your woods

- Rare plants or plant communities
- Rare animals or unique habitat features
- Streams, creeks, seeps, and other water features
- Wetlands, including vernal pools

Maintaining the ecological diversity of forests through the protection rare or sensitive plant and animal communities around streams, creeks, seeps, or wetlands—including vernal pools— can be important for sustaining the functioning of forest ecosystems.

Promote diversity in your forest (resilience).

Promote diversity in stand structure and tree species.

Tree species diversity

- Different tree species in case one performs poorly
- Species that are more tolerant of hotter and drier conditions

Structural/ tree size diversity

- Diversity of age classes, including different tree sizes
- Retain snags & downed dead wood
- Can increase resistance to strong winds

A resilience focused strategy includes promoting diversity in your forest. This includes promoting a diversity of tree species and age classes. The recognizes that maintaining different tree species is important if one species is hit by an insect or is impacted by other stressors, such as drought. Increased diversity maintains more option for maintaining productivity of the forest under a range of future condition, such as species that are tolerant of hotter or drier conditions or saturated soils. Similarly, having a diversity of age classes can increase resitance to disturbances such as strong winds, as well as increasing the ability of the system to recover when those disturbances do occur.

Promote diversity in your forest (resilience).

Promote a diversity of tree species and sizes.

Forest management

- Unhealthy trees targeted for removal (worst first)
- Keep trees of less common species
- Keep trees that may do well in future
- Retain good habitat

Other actions include removing unhealthy trees (worst first), keeping trees of less common species, keeping trees that may do well in future, and other actions that work to retain good habitat.

Promote diversity in your forest (resilience).

Promote a diversity of tree species and sizes.

Forest management practices = Thinning

- Removes some trees, providing more space to the remainder

Thinning is one action that is particularly effective at increasing resilience of remaining trees by providing more space, for example reducing the impacts of drought.

Promote diversity in your forest (resilience).

Promote a diversity of tree species and sizes.

Forest management practices = Patch or group selection

- Removes trees in a more concentrated area to promote regeneration of mid-tolerant and intolerant species, such as oak

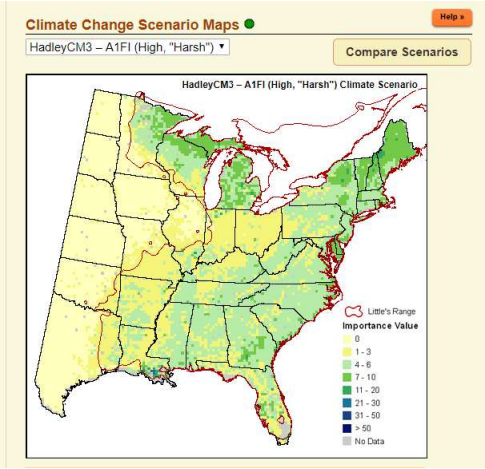
One final action for increasing the diversity of tree species and age classes is patch or group selection through concentrated removal to create a gap in the canopy that allows sunlight to hit the forest floor, and encourage the regeneration of certain species, such as mid-tolerant or intolerant species like oak and hickory.

Be pro-active to adapt your woods to changing conditions (transition).

Consider which tree species you might want to promote.

Trees adapted to future conditions

- Match trees to site
- Trees that can take a wide range of conditions
- Trees that can handle hotter & drier conditions



Climate Change Tree Atlas: www.fs.fed.us/nrs/atlas/

Finally, we can consider the strategies that prepare the forest for transitioning to be better adapted to future conditions. A common approach to this is identifying tree species that best match site conditions, tolerate a wide range of conditions, including hotter and drier conditions. The Climate Change Tree Atlas and resources such as the summaries of tree species “winners and losers” can help identify which tree species might be important for this.

Monitor your forest and the effect of different management tactics.

Monitor to determine the effectiveness of your actions!
Is your adaptation working? Are you reducing your climate risks and continuing to meet your management objectives?

- Identify important metrics that relate to your objectives.
- What criteria would you use to define success?

Be observant to changes in your woods

- Look for changes and "weird things"
- Early spring – many invasives green up first
- After big rains – soil erosion, sedimentation, ponding, etc.

Finally, we want to make sure we are paying attention to the effects of these management actions in order to determine their effectiveness. The ultimate goal is to practice adaptive management, so we should be making sure we understanding if these actions are reducing climate risks and impacts from associated stressors to help us keep meeting our management objectives. The most important things to keep in mind is that the monitoring metrics we are tracking relate to our objectives, and that we are defining what success is in meeting those objectives. For example, if your management objective is regeneration of a diversity of tree species following a harvest, you should be monitoring both regeneration with socking surveys, and measuring species diversity of seedlings.
It is also important to be keeping an eye out for changing conditions and new impacts from changing conditions, this means looking out for new invasives or new impacts from extreme precipitation events.